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A FERN APHID, *NEOMACROMYZUS CYRTOMICOLA* LEE, NEW GENUS AND NEW SPECIES (HEMIPTERA: APHIDIDAE) ON *CYRTOMIUM FALCATUM* (DRYOPTERIDACEAE) IN BASALT ROCK CAVES

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Abstract.—A new cave-living fern aphid, ***Neomacromyzus cyrtomicola* Lee, new genus** and **new species**, is recognized on *Cyrtomium falcatum* (L.) Presl. (Dryopteridaceae) in basalt rock caves located on Jeju Island, a volcanic island in the southernmost region of Korea. The new genus, *Neomacromyzus*, is established by the following characteristics: small body size (1.0–1.5 mm) with sooty black coloring and pale legs; short dorsal and marginal hairs, which are strongly capitate or flabellate; thorax and abdomen strongly wrinkled dorsally; and post-siphuncular sclerites strongly spinulate. A key to the genera of fern-infesting aphids in the eastern Palaearctic and the Indian subregions is presented.

Key Words: fern aphids, new genus, *Neomacromyzus*, key to genera, Far East Asia

Jeju Island is located in the southernmost region of the Korean Peninsula, its north latitude ranging from 33°19′10″ to 33°25′35″, and its east longitude ranging from 126 27′50″ to 126 37′55″. The island originated from four main volcanic eruptions in the Pleistocene period (1,200,000~30,000 years ago). There are numerous sizes of lava caves along with many basalt rock cliffs and volcanic cones, represented by Mt. Halla (1,950 m), which is located at the center of the island. The climate of Jeju Island is subtropical in the seaside lower elevations, typically temperate at higher elevations, and subarctic at the top of Mt. Halla. Therefore, the flora and fauna of Jeju Island is very rich, having more than 1,800 species of vascular plants and 79 known aphid species in the subfamily Aphidinae (Lee et al. 2002).

Cyrtomium falcatum (L.) Presl. (Dryopteridaceae) is a subtropical fern which typically grows in wooded, shady hollows or on shady basalt rock cliffs near the sea. With adequate sunlight, leaves of the *Cyrtomium falcatum* crown can grow to 40–80 cm long with up to 11 leaves. It is able to live in the humid, dark areas of lava caves that receive indirect sunlight, but, the plants remain small in caves, with few leaves larger than 10 cm in length.

There are seven aphid genera (*Macromyzus* Takahashi 1960; *Macromyzella* Ghosh et al. 1977; *Shinjia* Takahashi 1938; *Micromyzodium* David 1958; *Micromyzus* van der Goot 1917; *Taiwanomyzus* Tao 1963; *Amphorophora* Buckton 1876) that are known to live on various ferns in the eastern Palaearctic and the Indian subregions (Ghosh 1974; Ghosh

et al. 1977; Miyazaki 1968, 1971; Moritsu 1952; Takahashi 1921, 1938, 1960; David and Narayana 1968; Tao 1963). Among them, *Macromyzus woodwardiae* (Takahashi 1921) is the only aphid recorded on *Cyrtomium falcatum*, a fern common on Jeju Island. *Macromyzus woodwardiae* often can be found in large colonies on the underside of the young leaves, developing before the fruiting of spores, wherever the host plants occur (Lee 2002).

The tiny black aphid described below is found on the young plants of *Cyrtomium falcatum* which grow on rock walls in small, dark lava caves. The new aphid is not congeneric with any previously known aphid. In this context, *Neomacromyzus* Lee, n. gen., is established for the species *Neomacromyzus cyrtomicola* Lee, n. sp.

Materials and Methods

Samples of aphid colonies were preserved in 80% ethyl alcohol before slide preparations. Three to five adult specimens were placed in a plastic centrifuge tube of 95% alcohol and boiled on a heat block for 2–3 minutes (not necessary after being preserved in ethyl alcohol for more than 1 month). Thereafter, the ventral side of the abdomen of each specimen was punctured by a minute insect pin and macerated in 10% potassium hydroxide (KOH) for about 5 minutes. The macerated specimens were washed 5–6 times in distilled water for at least 5 minutes each time and dehydrated in glacial acetic acid. After being totally dehydrated, each specimen was cleared in clove oil for 10–20 minutes and, finally, mounted in a drop of Canada balsam on a slide (see Blackman and Eastop 2000 for details).

Illustrations for macerated specimens were taken by a digital camera (Baumer Optronic ARC HR33C, Germany), attached on an upright microscope (Leica DM 400B) at a resolution of 600 dpi. Measurements for each specimens also were taken with the digital images by software (Image Lab version 2.2.4.0, MCM Design (Ltd.)).

Abbreviations used for keys and descriptions are as follows: Ant.I, III, VIb–antennal segment I, III, base of VI, respectively; apt.–apterous viviparous female, aptera; Ant.IIIBD–basal diameter of antennal segment III; BL–length of body; A–length of entire antennae; 2HT–second segment of hind tarsus; PT–processus terminalis; SIPH–siphunculus; URS–ultimate rostral segment.

Systematics

Neomacromyzus Lee, new genus

Apterous viviparous female.—Body oval and small, 1.01–1.51 mm in length; entirely sooty black, except shiny black on abdominal terga 1–6 (Fig. 13). Appendages pale including antennal flagellum and siphunculus (Fig. 13). Head strongly spinulate both dorsally and ventrally, with 4 pairs of dorsal hairs (Fig. 9). Dorsal hairs on head capitate, 1.5–2.0 times as long as basal width of antennal segment III. Antennal tubercles well-developed, subparallel and strongly granulated, with single capitate hair on each side. Median tubercle on frons weakly developed with two pairs of capitate hairs. Antenna pale smooth or weakly imbricated with short blunt hairs and 1–2 secondary rhinaria on Ant.III (Fig. 7–8); primary rhinaria on Ant.V ciliate. Rostrum attaining hind coxae; mandibular laminae with 3 long acuminate hairs on each side; ultimate rostral segment 1.50–2.38 times as long as 2HT, 1.00–1.45 times as long as Ant.Vib, with two pairs of accessory hairs (Fig. 11). Thorax strongly wrinkled dorsally and reticulated marginally, with one pair of spinal hairs and 2 hairs on each marginal sclerite. Dorsal and marginal hairs on thorax strongly capitate or flabellate. Legs pale; first tarsal chaetotaxy 3:3:3.

Abdomen strongly wrinkled dorsally and spinulated ventrally. Postsiphucular sclerites strongly spinulated as in *Toxoptera* Koch 1856. Dorsal and marginal hairs on abdomen flabellate or strongly capitate (Figs. 3–4); abdominal tergum III with 3 pairs of spinal hairs and 2–3 hairs on marginal sclerites; abdominal terga VI and VII each with 1 pair of spinal hairs. Siphunculus cylindrical, well-fringed, and weakly tapering distally; darkly pigmented basally and pale distally (Fig. 5). Cauda short triangular, constricted in middle, with 4–5 long acuminate hairs (Fig. 12).

Remarks.—This genus can be distinguished from other aphid genera by the following characteristics: body small (1.0–1.5 mm), sooty black with pale appendages including legs, antennae, and siphunculus (Fig. 13); dorsal and marginal hairs short and strongly capitate or flabellate (Figs. 4, 13); thorax and abdomen strongly wrinkled dorsally (Figs. 1–2); and post-siphuncular sclerites strongly spinulate.

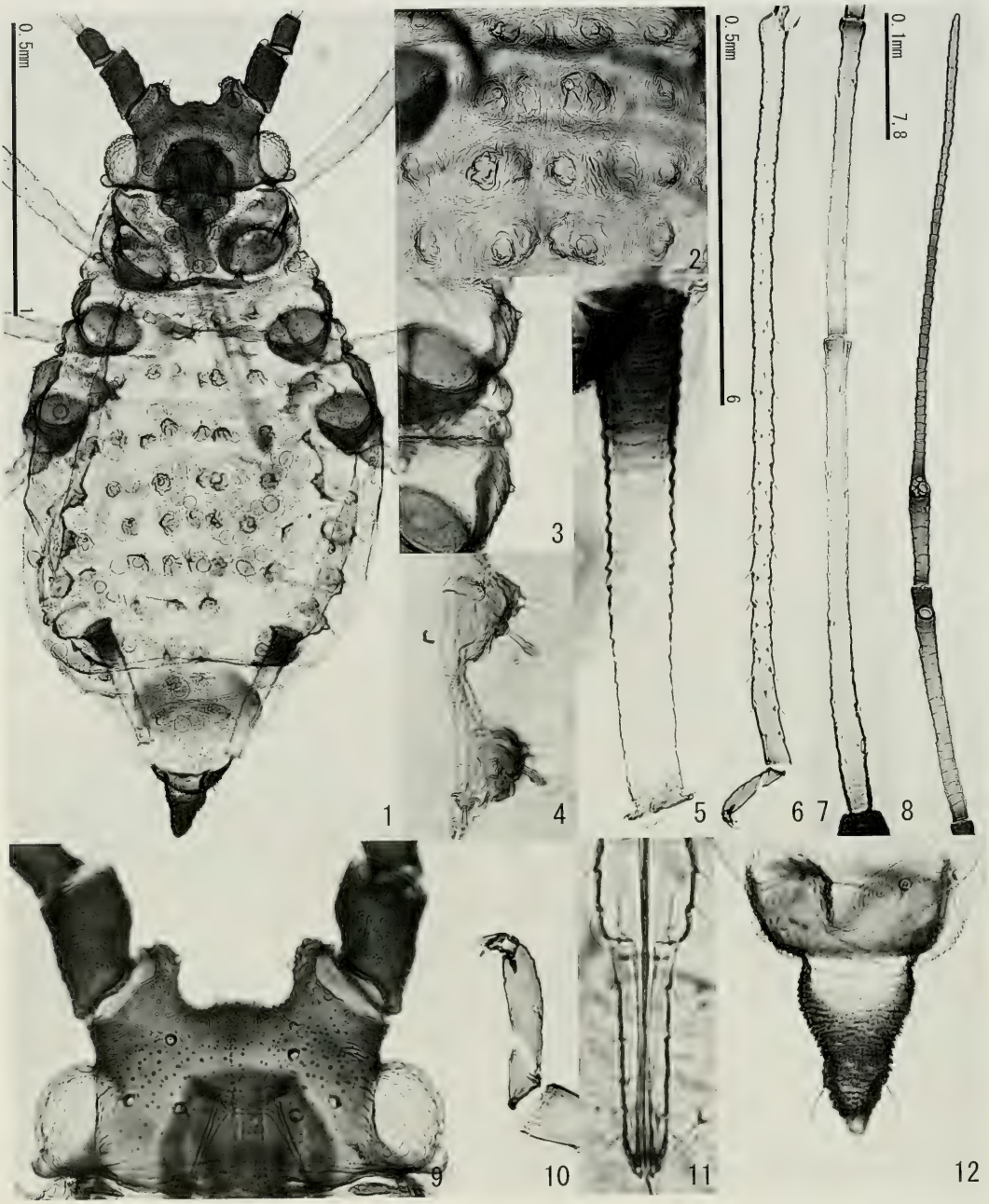
Neomacromyzus appears to be more closely related to the genus *Macromyzus* than the other fern infesting aphids, by the reticulated dorsum of abdomen, well-developed antennal tubercles, and infestation on the same host plant, *Cyrtomium falcatum*. The two may be distinguished by the following combination of characters (those of *Macromyzus* in parenthesis): siphunculus pale, cylindrical, and not reticulated, at most less than one row of reticulation at distal apex (entirely dark, constricted and strongly reticulated at distal 1/6); dorsal setae on body short and strongly capitate or flabellate (relatively long, blunt or weakly capitate at apex), ultimate rostral segments with 4–6 hairs (with 10–13 hairs); antennal segment III with 1–3 secondary rhinaria on basal half (without secondary rhinarium). The new genus also can be distinguished from the other aphid genera of the tribe Macrosiphini with well-developed frontal tubercles and capitate hairs (*Capitophorus, Pleotrichophorus, Chaetosiphon*) by the strongly elevated scleroites at the base of the dorsal setae on the thorax and abdomen, body small and sooty black, and the host limitation on ferns.

Etymology.—The name *Neomacromyzus*, is masculine and derived from Latin prefix *Neo-* (new) and the other sympatric genus name, *Macromyzus* living on the same host plant.

Type species.—*Neomacromyzus cyrtomicola* Lee, n. sp.

Key to the Genera of Fern-infesting Aphids in the Eastern Palearctic and Indian Subregions

1. Siphunculus with polygonal reticulations on distal apex on both apterae and alate 2
– Siphunculus not reticulated, at most one or two lines of wrinkles on distal apex (Fig. 5) 3
2. First tarsal chaetotaxy 4:4:4 or 4:4:3. Abdominal dorsum with darkly pigmented, tuberclelike, elevated scleroites at base of dorsal hairs. On various ferns: *Dryopteris, Rumobra, Woodwardia, Polystichum, Asplenium, Cyrtomium falcatum*. In far eastern and southern Asia (India, Korea, Japan, China, Taiwan) (Type species: *Myzus woodwardiae* Takahashi 1921) . . . . . *Macromyzus* Takahashi 1960
– First tarsal chaetotaxy 3:3:3. Abdominal dorsum evenly pale without elevated scleroites at base of dorsal hairs. Found on *Dryopteris arida* (Don) Kuntze, *Polystichum*, *Pteridium* (Pteridaceae). In Korea (Jeju-do), Japan, China (Sichuan), Taiwan, Indonesia (Sumatra), India (Type species: *Myzus polypodicola* Takahashi 1921) . . . . . *Macromyzella* et al. 1977
3. All legs with extremely reduced tarsi without claws. First tarsal chaetotaxy 1:0:0. Found on *Pteridium aquilinum* var. *latiusculum* Underw. ex A.Heller (Hypolepidaceae). In Korea, Japan, China (Zhejing, Sichuan), Nepal, India, Russia, Australia (Type species: *Microtarsus pterydifoliae* Shinji 1929 = *Atarsos orientalis* Mordvilko 1929) . . . . . *Shinjia* Takahashi 1938
– Tarsi not reduced, with claws. First tarsal chaetotaxy 3:3:3, 4:4:4, or 5:5:5 4
4. Dorsal setae strongly capitate or flabellate (Figs. 3–4). Thorax and abdominal dorsum with well-pigmented, elevated



Figs. 1–12. Apterous viviparous female of *Neomacromyzus cyrtomicola*. 1, Entire body. 2, Dorsal surface of anterior dorsum of abdomen. 3, Marginal setae of thorax. 4, Dorsal and marginal setae of abdominal tergite 5–6. 5, Siphunculus. 6, Hind tibia and tarsus. 7, Antennal segment III–IV. 8, Antennal segment V–VI. 9, Head and antennal segment I. 10, Hind tarsus. 11, Ultimate rostral segment. 12, Cauda.

Fig. 13. Apterous viviparous female of *Neomacromyzus cyrtomicola* on a young leaf of *Cyrtomium falcatum*.

scleroites at base of dorsal setae (Figs. 2, 4). Tiny black aphid (Fig. 13). On *Cyrtomium falcatum* in Korea (Jeju-do) (Type species: *Neomacromyzus cyrtomicola*, n. sp.) . . . . . *Neomacromyzus*, n. gen.

– Dorsal hairs acuminate or blunt, not capitate or flabellate. Base of dorsal setae on thorax and abdomen low, not elevated 5

5. Apterae without secondary rhinaria on antenna. Head spinulous, both dorsally and ventrally. Antennal tubercles divergent. On various ferns: *Adiantum, Lastrea, Nephrolepides, Pitygramma, Polypodium, Pteris, Streptocarpus, Asplenium, Digitaria*. In India, Japan (Type species: *Micromyzodium filicium* David 1958) . . . . . *Micromyzodium* David 1958

– Apterae with secondary rhinaria on antenna. Head smooth or scabrous on dorsum, if scabrous, antennal tubercles strongly converging. 6

6. Siphunculus cylindrical. Antenna and tibiae entirely black. On *Osmunda, Athyrium*. In Korea, Japan, China, Taiwan, India (Type species: *M. niger* van der Goot 1917) . . . . . *Micromyzus* van der Goot 1917

– Siphunculus swollen. Antenna and tibiae paler at base than other parts. 7

7. Body small, less than 2 mm in length. Head scabrous dorsally with short blunt hairs. Antennal tubercles strongly convergent. Abdomen with well-pigmented sclerites or scleroites on spinal or marginal region. Cauda normally with 4 hairs. On *Athyrium, Dryopteris, Osmunda, Astilbe, Chrysosplenium*. In Japan, India, Taiwan (Type species: *Myzus montanus* Takahashi 1925) . . . . . *Taiwanomyzus* Tao 1963

– Body usually larger than 3 mm in length. Head smooth with long acuminate hairs. Antennal tubercles divergent or parallel. Abdomen membranous. Cauda with more than 10 hairs. On various ferns (*Athyrium, Lastrea, Pteris, Asplenium*), *Rubus, Geranium, Filipendula, Cryptotaenia, Anemone*. Widely distributed in Pa-

laearctic and Nearctic Regions (Type species: *Amphorophora ampullata* Buckton 1876) . . . . . *Amphorophora* Buckton 1876

Neomacromyzus cyrtomicola Lee, new species

(Figs. 1-13)

Apterous viviparous.—*Color* (in life): Body sooty black, with pale white capitate or flabellate hairs. Legs pale. Siphunculus pale, except black basal part. Cauda black. Antenna pale, except black Ant.I-II, becoming gradually dusky towards distal apex (Fig. 13). Color (in macerated specimens): head dark brown, antenna dark brown on Ant.I-II, pale brown on Ant.III-VI, developing dusky color at distal apex of each segment. Clypeus, mandibular laminae and anteclypeus concolorous with head; rostrum pale, except dark distal end of URS. Thorax pale brown, except dark brown marginal sclerite on each segment. Legs pale, except dark brown coxae and pale brown tarsi. Abdomen pale brown with pigmented scleroites on each elevated base of setae. Genital plate brown. Cauda dark brown. Siphunculus pale on distal 2/3, dark brown on basal 1/3.

Morphology: Body oval and small, 1.01–1.51 mm long from antennal tubercle to end of cauda. Head strongly spinulate both dorsally and ventrally with 4 pairs of dorsal hairs, 3 pairs of ventral hairs, and frequently 1–2 additional irregularly located hairs. Dorsal hairs on head capitate and 1.5–2.0 times as long as Ant.IIIBD. Antennal tubercles well developed and strongly granulated with a single hair on each side; inner side of each tubercle parallel (Fig. 9). Median tubercle of frons weakly developed. Antenna 1.45–1.84 mm long; Ant.I–Ant.VI, 0.07–0.11, 0.06–0.41, 0.29–0.44, 0.21–0.29, 0.20–0.30, (0.09–0.13) + (0.41–0.57) (Ant.VIb + PT), respectively. Ant.I–II granulated with 7–11 and 4–6 short blunt hairs, respectively. Ant.III smooth on basal half and weakly imbricated on distal half, with 1 secondary rhinarium at base along with 8–15 short blunt hairs. Longest hair on antenna distinctly shorter than Ant.IIIBD. Ant.IV–V imbricated; primary rhinarium on Ant.V ciliate; longest diameter of primary rhinarium as long as or slightly shorter than middle width of segment; Ant.VI strongly imbricated with 2–3 hairs on Ant.VIb; PT 3.37–5.42 times as long as Ant.VIb. Rostrum attaining hind coxae; mandibular laminae with 2–4 long acuminate hairs on each side; ultimate rostral segment long, 1.50–2.38 times as long as 2HT, 1.00–1.45 times as long as Ant.VIb with two pairs of accessory hairs (Fig. 11). Thorax strongly wrinkled dorsally or reticulated marginally with one pair of spinal hairs and 2 marginal hairs on each side; hairs short, clavate or flabellate, and based on elevated tuberclelike scleroites. Hind coxae spinulate with 7–8 long acuminate hairs. Trochanters and femora mostly smooth with ca. 35 short hairs; longest hair on hind femur 1/2 of basal diameter of femur. Hind tibia smooth, with acuminate hairs; longest hair on tibiae shorter than diameter of the middle. First tarsus smooth; first tarsal chaetotaxy 3:3:3; 2HT weakly imbricated with 4–5 short acuminate hairs. Abdomen strongly wrinkled dorsally, spinulate ventrally. Dorsal hairs on abdomen short and strongly flabellate on anterior segments and clavate on posterior segment, based on pigmented, elevated scleroites (Figs. 3–4). Tergum III with 3 pairs of dorsal hairs and 2–3 hairs on marginal sclerites. Tergum VI with 2 hairs between siphunculi. Tergum VII with 2 spinal hairs and 2–3 marginal hairs on each side. Tergum VIII with 4 acuminate or weakly capitate hairs. Siphunculus cylindrical, imbricate, well-flanged at apex, weakly tapering distally, 1.92–2.30 times as long as cauda (Fig. 5). Post-siphuncular sclerite dark-pigmented

Table 1. Biometric data of apterous viviparous females of *Neomacromyzus cyrtomicola*.

	Part	Apterous Vivipara (n = 17) Mean	Range
Length of (mm)	Body from antennal tubercle to caudal end (BL)	1.28	(1.01–1.51)
	Entire antennae (A)	1.63	(1.45–1.84)
	Antennal segment I (Ant.I)	0.09	(0.07–0.11)
	Antennal segment II (Ant.II)	0.08	(0.06–0.41)
	Antennal segment III (Ant.III)	0.38	(0.29–0.44)
	Antennal segment IV (Ant.IV)	0.25	(0.21–0.29)
	Antennal segment V (Ant.V)	0.25	(0.20–0.30)
	Base of antennal segment VI (Ant.VIb)	0.11	(0.09–0.13)
	Processus terminalis of Ant.VI (PT)	0.48	(0.41–0.57)
	URS (Ultimate Rostral Segment)	0.13	(0.12–0.14)
	Hind femur	0.53	(0.44–0.63)
	Hind tibia	0.96	(0.81–1.09)
	Second segment of hind tarsus (2HT)	0.07	(0.06–0.08)
	Siphunculus (SIPH)	0.26	(0.21–0.31)
	Cauda	0.12	(0.11–0.14)
	Setae on Ant.III	0.01	(0.01–0.02)
	Setae on Tergite VI	0.02	(0.02–0.03)
No. of hairs on	Mandibular lamina	3	(2–4)
	Ant.I	9	(7–11)
	Ant.II	4	(4–6)
	Ant.III	12	(8–15)
	URS	6	(4–6)
	Tergite VI between SIPH	2	(2–2)
	Tergite VIII	4	(3–4)
	Median of Genital plate (GP)	2	(2–2)
	Posterior margin of GP	11	(7–14)
	Cauda	5	(4–6)
No. of Rhinaria on	Ant.III	2	(1–3)
Ratio (times)	Entire Antennae (A) / Body Length (BL)	1.30	(1.05–1.83)
	PT / Ant.VIb	4.42	(3.37–5.42)
	PT / Ant.III	1.27	(1.07–1.93)
	URS / 2HT	1.78	(1.50–2.38)
	URS / Ant.VIb	1.19	(1.00–1.45)
	SIPH / Body	0.21	(0.17–0.26)
	SIPH / Ant.III	0.69	(0.55–1.00)
	SIPH / Hind femur	0.49	(0.41–0.55)
	SIPH / Cauda	2.12	(1.92–2.30)
	Cauda Length/Basal width	1.66	(1.36–1.96)
	Setae on Ant.III / Ant.IIIBD	0.78	(0.39–1.09)
	Setae on Tergite VI / Ant. IIIBD	1.45	(0.77–2.19)

and strongly spinulate as ventral stridulatory apparatus of *Toxoptera*. Cauda short triangular, constricted in middle, strongly spinulate dorsally and ventrally, with 4–6 long acuminate hairs (Fig. 12).

Etymology.—The species name is derived from the genus name of the host plant *Cyrtomium* and the Latin suffix –*cola* (inhabitant of, dwelling in, living among).

Biology.—All type specimens were collected on young, small plants of *Cyrtomium falcatum* which were living on rock walls in basalt caves on Jeju Island, Korea. No specimens have been found on large, full-grown plants of *C. falcatum*, although the other fern-infest-

ing aphid, *Macromyzus woodwardiae* (Takahashi, 1921), is very common on *C. falcatum* plants which grow in rather bright areas of the woody/shady places on Jeju Island. The colonies of *N. cyrtomicola* were found on both the upper and lower sides of the young leaves and on young shoots that had not spread leaves, whereas *M. woodwardiae* is found only on the shady underside of newly grown leaves of the larger plants. It seems that *N. cyrtomicola* is adapted to young, small plants found growing in dark and humid volcanic rock caves. Winged adults have not been observed. Presumably, they are monoecious and holocyclic on *C. falcatum.*

Type material.—Holotype: apterous viviparous female, CALS SNU collection specimen no. 020415-SH31/apt.17, KOREA(South), Jeju-do (Island), Namjeju, Seongsan, Illchul-bong, in volcanic rock cave, 17.iv.2002, on *Cyrtomium falcatum,* leg. Seunghwan Lee. Paratypes: 16 apterous viviparous females and three nymphs in same collection as holotype; five apterous viviparous females and one nymph, CALS SNU collection specimen no. 040527-HJ-001, KOREA(South), Jeju-do (Island), Namjeju, Seongsan, Illchul-bong, in volcanic rock cave, 27.v.2004, on *C. falcatum,* leg. Hyojoong Kim. The type specimens, including the holotype, are deposited in the College of Agriculture and Life Sciences, Seoul National University (CALS SNU), Seoul, Korea. Five paratypes (collection number 020415-SH31) are also located at the Insect Museum of the National Institute of Agricultural Sciences and Technology (NIAST, Suwon), Korea.

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